

Fine-scale Focal Dtag Behavioral Study of Diel Trends in Activity Budgets and Sound Production of Endangered Baleen Whales in the Gulf of Maine

Susan E. Parks

The Pennsylvania State University, Applied Research Laboratory
P.O. Box 30, State College, PA 16804-0030
phone: (814) 865-7683 fax: (814) 863-8783 email: sep20@psu.edu

David Wiley

Stellwagen Bank National Marine Sanctuary
175 Edward Foster Rd., Scituate, MA 01938
phone: (781) 545-8026 x 211 email: David.Wiley@noaa.gov

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LONG-TERM GOALS

The long-term goals of this project are to obtain crucial baseline data on the normal diel activity budgets of endangered baleen whale species including time spent at the surface, residency time and rate of horizontal travel, and rates of sound production. These data can be used to assess both visual and passive acoustic detectability to aid in their detection to protect them from vessel collisions and harmful exposures to man-made sounds. These data also provide data on normal behavior, necessary to interpret any potential disturbance responses to human activities.

OBJECTIVES

The primary goal of this project is to obtain fine-scale behavior data from two endangered baleen whale species, the humpback whale (*Megaptera novaengliae*) and the right whale (*Eubalaena glacialis*), on the Stellwagen Bank National Marine Sanctuary through suction-cup attachment of sound and orientation recording tags (Digital Archival Tag - Dtag), which records subsurface movements and sound production by the whale. The specific objectives of this three year study are to use these tag data to: 1) determine the diel trends in dive profiles and horizontal movement patterns for tagged humpback and right whales on the Stellwagen Bank National Marine Sanctuary; 2) determine the sound production behavior of individual tagged humpback and right whales on the Stellwagen Bank National Marine Sanctuary; and 3) examine the relationship among anthropogenic noise, conspecific sounds, and tagged whale behavior for humpback and right whales on the Stellwagen Bank National Marine Sanctuary.

APPROACH

The approach for this study utilizes a combination of techniques to obtain data on the behavior of individual whales and their surrounding environment. The primary method in the study involves Dtag attachment to document the activity budgets, movement patterns, and sound production of humpback and right whales on and around the Stellwagen Bank National Marine Sanctuary on three cruises from 2008-2010. These data will be collected using the Dtag (Johnson and Tyack 2003) in collaboration with the Woods Hole Oceanographic Institution in three field trails in the summer of 2008, and the

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spring of 2009 and 2010. When possible, parameters measured by the Dtag will be related to external cues including: 1) trends in prey biomass distribution in the water column from an active acoustic monitoring station; and 2) social sounds from conspecifics and man-made noise sources through collaboration with the NOPP led by Dr. Christopher Clark at Cornell University. These combined datasets will be used to infer diel trends in natural behavior of the whales, how the whales respond to man-made noise sources in their environment, and the effectiveness of passive acoustic monitoring in detection and tracking of individual whales.

The first cruise occurred in June and July 2008 and involved Dtag attachment to humpback whales on the Stellwagen Bank National Marine Sanctuary. The goal of this field study was to establish baseline tag data to correlate tag records with surface observations and to establish protocols for integration of the multiple datasets used for this study. These datasets include individual whale behavior from tags, trends in prey from the active acoustic moorings, AIS tracks of ships moving through the sanctuary during tagging, and noise and conspecific vocalization data from the ongoing NOPP project.

In Year 2 and 3, we will attempt to attach Dtags to both right whales and humpback whales in April and early May. Tag data will be analyzed to assess the activity budget, movement patterns and vocalization rates of the whale. The goal is to attach tags in the afternoon to allow for collection of both day and night-time data. Focal follows will be conducted of whales carrying the tag during daylight hours to obtain surface positions of the whales and to establish baseline data to correlate tag records with surface observations. Tag attachment to both species is planned to allow for comparisons of the behaviors of the two species. The active acoustic mooring will be deployed for the duration of this trial to monitor movement of potential prey items vertically in the water column. These data sets will be integrated to assess whale movement patterns related to sounds in the environment (both natural and man-made) and to prey movements vertically in the water column over time.

This project brings together collaborators from a number of institutions with specialized expertise in different aspects of this project. The major participating institutions in the data collection and analysis include the Pennsylvania State University Applied Research Laboratory (Susan Parks & Jennifer Miksis-Olds), the Stellwagen Bank National Marine Sanctuary (David Wiley), and the Woods Hole Oceanographic Institution (Alessandro Bocconcelli). Data integration is planned through a collaborative effort with the NOPP led by Dr. Christopher Clark at Cornell University, involving the Stellwagen Bank National Marine Sanctuary (Leila Hatch) and the Northeast Fisheries Science Center of the National Marine Fisheries Service (Sofie Van Parijs).

WORK COMPLETED

Dtag attachment to humpback whales

During the first five months of the project, all necessary equipment was obtained and prepared for a preliminary three week research cruise for active acoustic mooring deployment and suction cup tagging of humpback whales conducted on the Stellwagen Bank National Marine Sanctuary between June 26 – July 14, 2008. Dtags were successfully attached and recovered from 15 humpback whales, resulting in ~ 92 hours of movement and acoustic data. Tags were attached to whales near recording units from the NOPP array (Figure 1) and three whales traveled within the array during tag attachment. All tagged whales remained < 5 nm from at least one recording unit, providing a substantial dataset to integrate with the NOPP acoustic monitoring system. Analysis of the movement data and acoustic recordings from the tagged whales are currently ongoing. Integration with the NOPP project is planned for the winter of 2008.

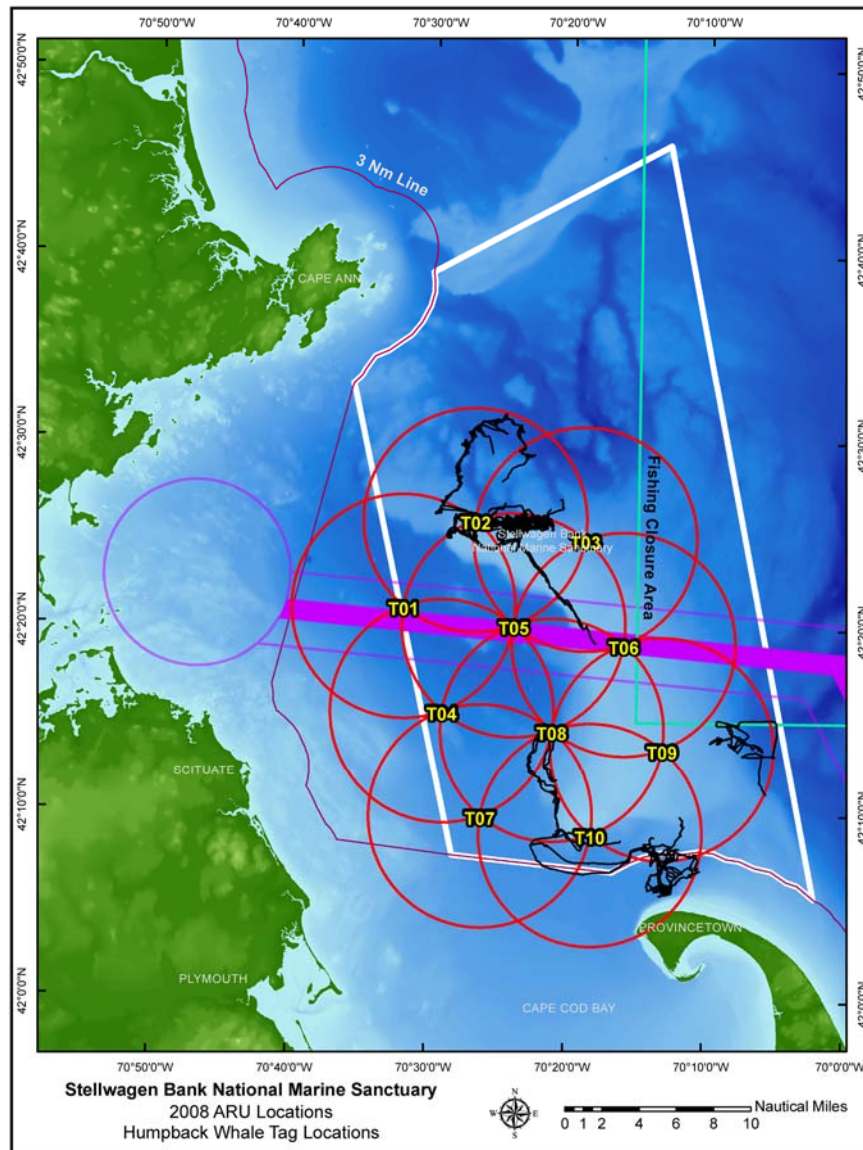


Figure 1. Surface positions of humpback whales tagged during the June/July 2008 Stellwagen Bank National Marine Sanctuary Cruise. The yellow labels T01-T10 represent positions of the bottom-mounted acoustic recording array from the collaborative NOPP project. The red circles are 10 nm in diameter, estimating the potential range of acoustic detection of the tagged whale's calls. The active acoustic monitoring station was located at close to the T10 recorder position on the southern end of the Sanctuary. Map created by Michael Thompson, Stellwagen Bank National Marine Sanctuary.

Active Acoustic Monitoring Station

The three-frequency, active acoustic mooring station (AWCP mooring) was deployed in the SBNMS for 18 days (June 27 - July 14, 2008) to detect right and humpback whale prey. Vertical plankton tows of the full water column and the top 5 m of the water column were made using a 250 μ m mesh net

immediately after deployment and before retrieval of the mooring station. Plankton samples were stored in a 10% formalin solution for later species identification and counting. Additional video samples were made with a drop video camera at the site of the mooring after deployment and after recovery. The mooring was set in approximately 30 m of water with the instruments at a depth of 25 m. The sampling protocol was designed to sample in 30 minute cycles that were repeated for the duration of the deployment. During each 30 minute cycle, all frequencies (125 kHz, 200 kHz, and 460 kHz) sampled simultaneously for the first 10 minutes. This was followed by a 5 minute period with simultaneous sampling at 125 kHz and 460 kHz. Individual frequency sampling was conducted for 5 minutes per frequency during the last 15 minutes of the cycle. This regime was implemented to determine the level of cross talk between frequencies during simultaneous sampling periods. Upon retrieval, data from the AWCP sensors were downloaded and verified for proper instrument function.

RESULTS

Dtag attachment to humpback whales

Data collected from the first cruise are currently being analyzed. Preliminary results from the Dtag analysis include horizontal travel distances for individual tagged whales (Table 1), and indicate a change in dive patterns (Figure 2) of humpback whales between day and night time hours. Analysis by the University of New Hampshire (Ware *et al.*, 2006) allowed for visualization of the 3-dimensional aspects of the dive behavior of each whale (Figure 3), which provides substantially more information on subsurface behaviors than the simple dive profiles seen in Figure 2.

Table 1. Summary of the horizontal travel distances for a subset of tagged humpback whales from June and July 2008. Initial results indicate that most of the tagged whales stayed within a general area, rather than swimming in straight line directional travel.

| Date | Tag Event | Animal | Tag attachment duration (hr) | Distance between tag attachment and retrieval (km) | Rate of travel (km/hr) |
|------------------------------------|-----------|---------------|---------------------------------|----------------------------------------------------|-----------------------------------|
| 6/30/08 | mn182a | Lavalier | 18.52 | 5.57 | 0.30 |
| 7/1/01 | mn183a | Cajun | 5.68 | 10.41 | 1.83 |
| 7/1/01 | mn183b | Perseid | 6.4 | 2.64 | 0.41 |
| 7/2/08 | mn184a | Etch-A-Sketch | 8.83 | 0.64 | 0.07 |
| 7/2/08 | mn184b | Nile | 12.53 | 0.95 | 0.08 |
| 7/2/08 | mn184c | Pepper | 4.68 | 3.19 | 0.68 |
| 7/7/08 | mn189a | Falcon | 17 | 10.88 | 0.64 |
| 7/7/08 | mn189b | Hancock | 4.43 | 5.89 | 1.33 |
| 7/8/08 | mn190a | Cardhu | 3.47 | 5.22 | 1.50 |
| 7/10/08 | mn192a | Etch-A-Sketch | 4.55 | 0.38 | 0.08 |
| 7/11/08 | mn193c | Venom | 0.8 | 3.30 | 4.12 |
| 7/14/08 | mn196a | Isthmus | 4.73 | 4.95 | 1.05 |
| 7/14/08 | mn196b | Colt | 0.52 | 6.99 | 13.44 |
| Average \pm SD | | | 7.1 \pm 5.6 | 4.69 \pm 3.37 | 1.96 \pm 3.62 |

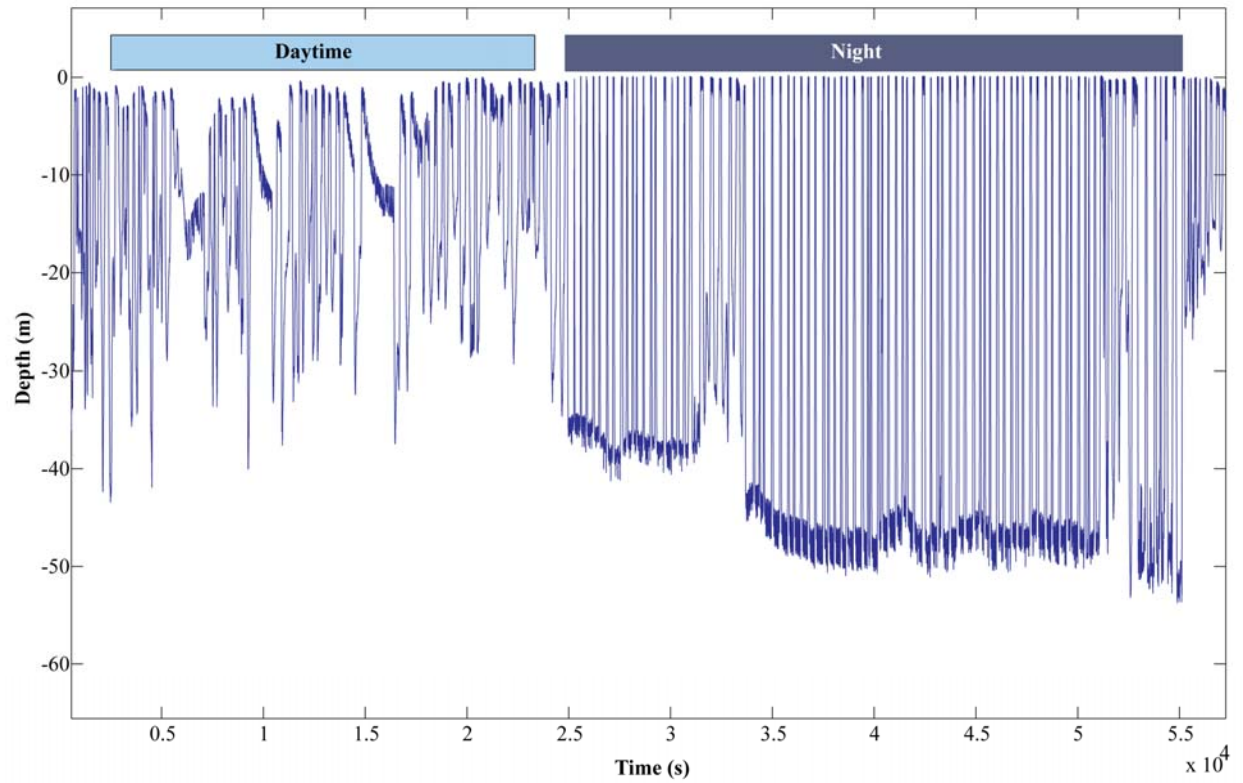


Figure 2. Dive profile from humpback whale mn08_189a, ‘Falcon’, tagged at 2:30 pm. The tag came off at 7:30 am the following morning, providing both daytime and night diving patterns. Each of the three whales tagged through the night showed a change in dive pattern that occurred at dusk.

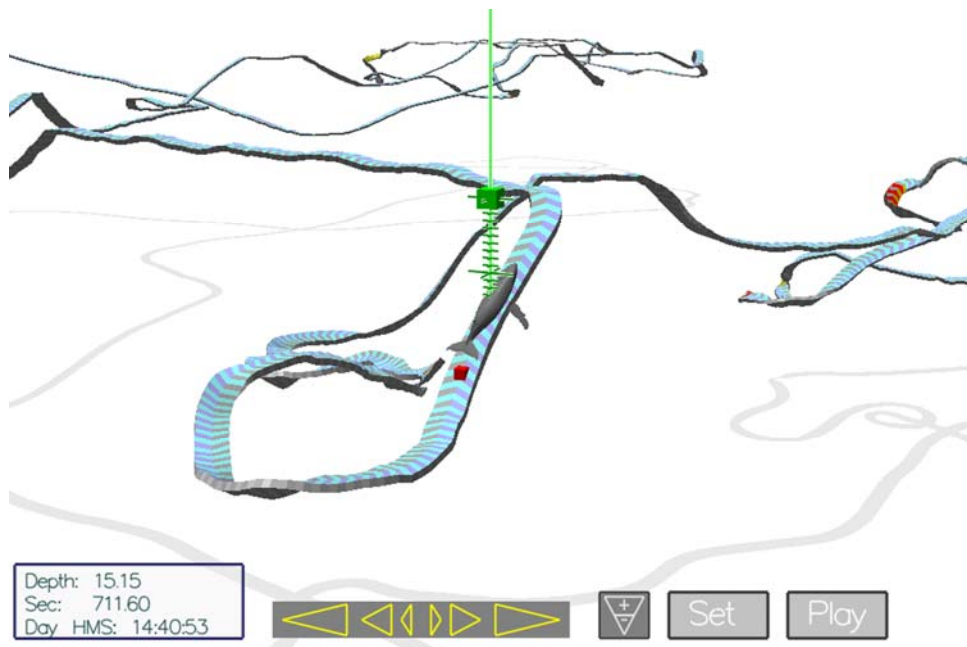


Figure 3. Visualization of the dive profile from whale mn08_189a, ‘Falcon’, 10 minutes after tag attachment showing the foraging behavior that accompanied this shallow dive using TrackPlot, software developed by Colin Ware at the University of New Hampshire. Note this is from the same tag record displayed in Figure 2.

Active Acoustic Monitoring Station

Data were successfully recorded for the entire deployment for all frequencies. Formatting of acoustic backscatter data for viewing with EchoView software has been completed. Preliminary data highlights include humpback whale tracks observed when a mother and calf were surfacing in the vicinity of the mooring (Figure 4), vertical migrations of zooplankton (Figure 5), fish schools, and individual fish targets. No cross-talk was observed during simultaneous sampling with the three frequencies. Zooplankton samples were obtained during deployment and retrieval. These samples will be used to identify the dominant zooplankton species, which will direct the proper model for calculation of biomass estimates. In addition, drop-camera profiles were recorded during deployment and retrieval to identify fish species and position in the water column. Detailed analysis in the coming year will examine the temporal and vertical spatial distribution of acoustic targets in the water column.

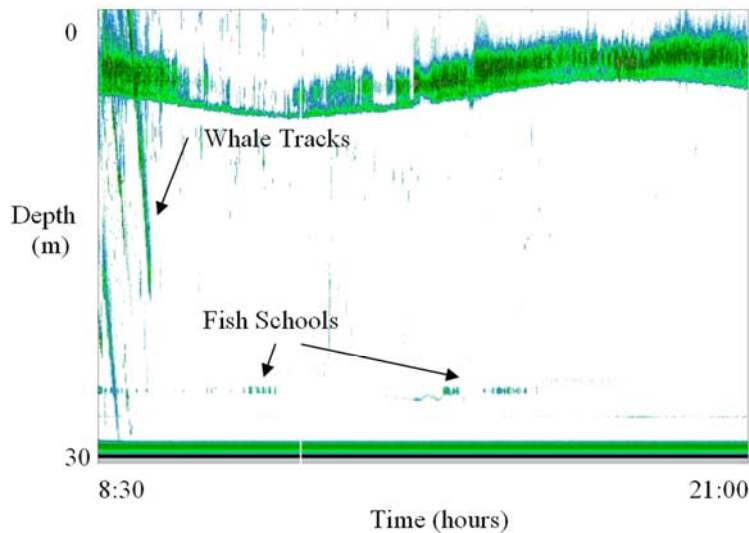


Figure 4. *Acoustic backscatter at 125 kHz on June 27, 2008. Two humpback whales were observed surfacing around the mooring after deployment and their acoustic signatures were evident at this frequency. Fish schools were detected near the sea bottom.*

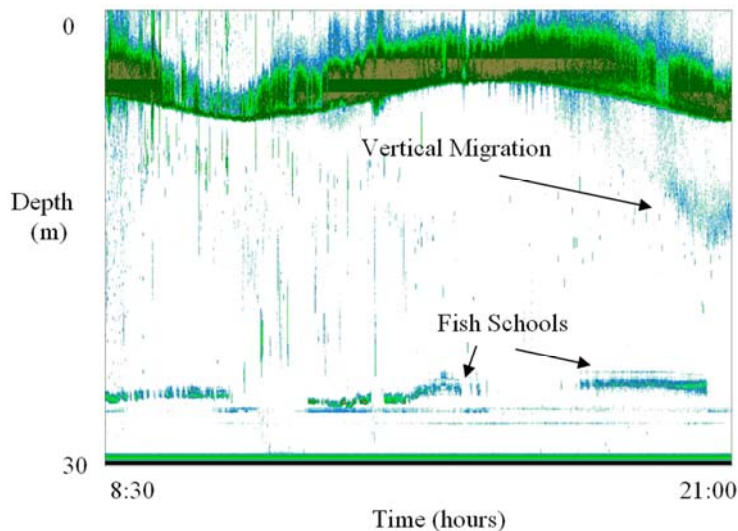


Figure 5. *Acoustic backscatter at 200 kHz on June 29, 2008. Vertical migration of zooplankton was detected in the evening hours. Fish aggregations were detected close to the seafloor.*

IMPACT/APPLICATIONS

The impacts of this work will provide baseline data on the ‘normal’ behavior of two species of endangered baleen whales on their foraging grounds, including diel trends in vocal behavior and movement patterns. Data on these two aspects of behavior are necessary to improve the detection rate of whales through both visual and passive acoustic surveys. Additionally, a current knowledge gap of the ‘normal’ behavior of particular marine mammal species makes it difficult to interpret any apparent

behavioral changes resulting from response to naval activities. These data can be used to aid in the interpretation of future targeted disturbance studies and will help determine whether baleen whales spend more time at the surface at night, making them more vulnerable to vessel collision. These two species, the humpback whale (*Megaptera novaeangliae*) and the right whale (*Eubalaena glacialis*), have been selected for several reasons. Both species are endangered, vulnerable to vessel collision and entanglement with fixed gear, and have a wide global distribution. Several humpback whale stocks are showing stronger recovery than right whales, despite overlapping habitat usage on the feeding grounds in the Northern hemisphere. One aim of the study is to determine if comparisons of the behavior between the two species may shed light on the reasons for the differences in recovery of the two populations.

RELATED PROJECTS

NOPP - “An Ocean Observing System for Large-Scale Monitoring and Mapping of Noise Throughout the Stellwagen Bank National Marine Sanctuary”, led by Dr. Christopher Clark at Cornell University is collecting continuous acoustic recordings from passive acoustic recording devices distributed in an array in the Stellwagen Bank National Marine Sanctuary during the tagging cruise in this project. The data collected in this study will provide ground truth data for the NOPP system when a tagged whale travels through the array. The Dtag data will provide precise surface location and times and depths for vocalizations produced by individual whales. This will allow for verification of the NOPP system to see if the observing system detected all vocalizations produced by the whale. These data will also determine what percentage of the time an individual may be ‘missed’ by the NOPP system. The NOPP array potentially can provide information about the location and levels of external acoustic cues that the tagged whale may be responding to.

REFERENCES

Colin Ware, Roland Arsenault, Matthew Plumlee, David Wiley, 2006. Visualizing the underwater behavior of humpback whales. IEEE Computer Graphics and Applications, 26(4), 14-18.

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